Battle Creek Sediment Study

Prepared for
Ramsey Washington Metro Watershed District

November 2002

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1.0 Introduction

The Board of Managers for the Ramsey-Washington Metro Watershed District requested that a study be performed to determine the most feasible approach to managing the silt and sediment load in Battle Creek's lower ravine. The lower ravine consists of the reach of Battle Creek from just northeast of Upper Afton Road downstream to the outfall west of Highway 61.

This report summarizes the analysis of the tributary drainage area, the primary sources of sand and silt, and some possible management approaches that may decrease the silt and sediment load reaching the lower ravine and increase the length of time between "cleanings"

2.0 Background

In 1983, the Ramsey-Washington Metro Watershed District (District) completed Battle Creek Restoration project. A significant a part of this project involved the stabilization of the Battle Creek Lower ravine area, located between Upper Afton Road and Highway 61. The reach had experienced significant erosion within the ravine. The stabilization involved, in part, the filling and re-vegetating of eroded areas within the ravine, installation of an underground flood flow storm sewer system, and the construction of an aboveground low-flow channel. To stabilize the low-flow channel, the longitudinal bottom slope was flattened and waterfall drop structures were added. The slower flows resulting from the flattened channel slope achieved the objective of minimizing erosion. However, the slower flows in the channel also tend to promote the settling of any silt and sediment being conveyed by or suspended in the water.

Over time silt and sediment accumulate and vegetation becomes established in the deposited material in the channel. The vegetation (predominantly reed canary grass and cattails) further slows flows, which in turn results in further silt and sediment deposition and excessive accumulations throughout the entire length of the lower ravine channel (approximately 4,800 lineal feet). The resulting conditions are shown in Photos 1 and 2. The accumulated silt, sediment, and vegetation cause much of the flow in the channel to enter the inlets to the underground flood flow storm sewer. Much of the creek literally "disappears" into the underground flood flow storm sewer.

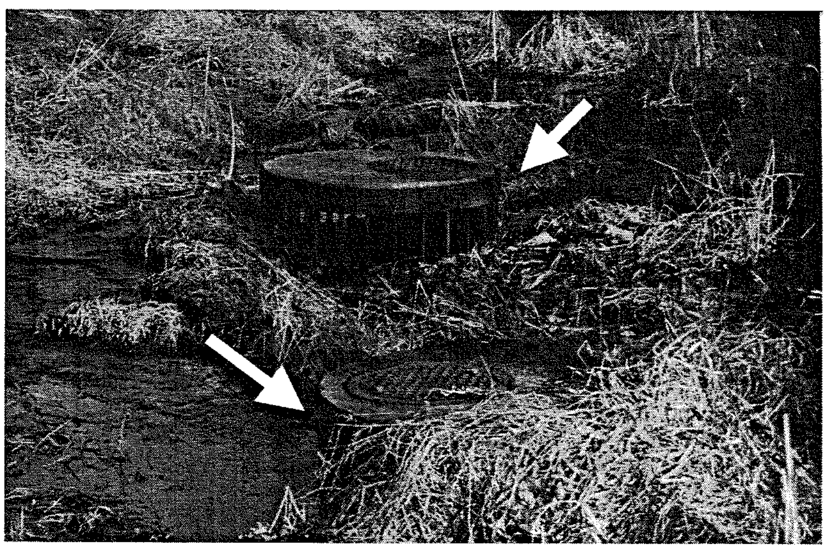


Photo 1: Low flow channel filled with silt, sediment, and vegetation causing flow to drain into the underground storm sewer.

The remaining low flow water in the channel gets "lost" as it flows through the heavy vegetation. The channel appears to be a dry ditch covered with reed canary-grass and a few cattails. (See Photos 2 and 3.) More important than its' appearance, the channel, in this overgrown state, lacks the capacity to convey the storm runoff for which it was designed.

Photo 2: The low flow channel with the appearance of a dry, reed canary-grassed

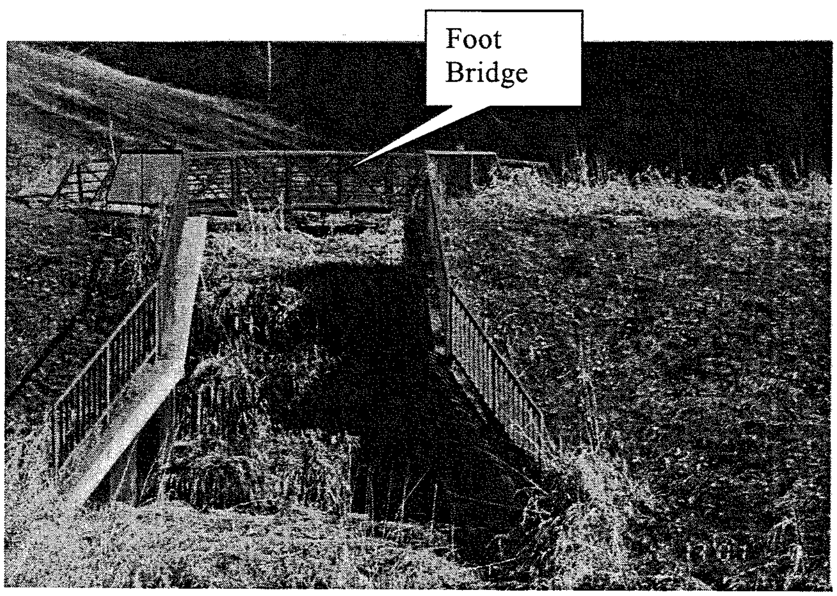


Photo 3: A drop structure in the Lower Ravine with just a trickle of water flowing over it.

Following the channel reconstruction in 1983, silt, sediment, and vegetation began to accumulate. Finally during the winter of 1991-1992, the silt, sediment, and vegetation needed to be and were removed from the creek channel. The maintenance work restored the creek channel at a cost of about $50,000.

It soon became apparent, however, that silt, sediment, and vegetation were reclaiming the creek channel. Again during the winter of 2002, the silt, sediment, and vegetation were removed from the creek channel. The maintenance work restored the creek to it's original channel shape at a cost of about $100,000. It was observed that much of the material removed from the channel appeared to be vegetative materials (root mass and dead and decaying vegetation). Although it had been 10 years since the previous channel cleaning, correspondence and meeting minutes disclose that discussions regarding the need for another creek channel cleaning actually began in 1998. These discussions indicate that removal of silt, sediment, and vegetation would have benefited the creek channel at least as early as 1998, possibly before then. Therefore, given the current drainage patterns and practices within the tributary drainage area, it is reasonable to assume that creek channel will need to be "cleaned" about every 5 years.

3.0 Tributary Drainage Area

The tributary drainage area for this study is comprised of three subwatershed areas. These subwatershed areas are the Suburban Pond Subwatershed, the Upper Afton Road Subwatershed, and the Ruth Street Subwatershed. These subwatersheds areas, along with the existing storm sewer systems, are shown in Figure 1. The individual watershed designations in this figure are consistent with those used in the District's 1997 Water Management Plan.

Those portions of the Battle Creek drainage area upstream of McKnight Road were not included in this study. The system of ponds upstream of McKnight Road appears to effectively remove sediment and suspended solids from this tributary area. Therefore, for the purposes of this study, only the 850-acre drainage area downstream of McKnight Road was analyzed.

For drainage areas comprising these three subwatersheds the portions of pervious and impervious areas were determined. Of those portions, the area of roadways and driveways/parking lots were also determined. The land use in each drainage area was divided into either commercial or residential use, and, the overall slope of each drainage area was characterized. These drainage area characteristics are summarized in Figure 4.

Each of the three subwatersheds and their contributing drainage areas are briefly described below.

3.1 Suburban Pond Subwatershed

Prior to the Battle Creek Restoration Project, a large portion of this area drained directly to Battle Creek just upstream of Upper Afton Road. However, as part of that project, flows from a large area north of I-94 near Van Dyke Street extended were diverted into and through a wetland area south of Suburban Avenue and east of White Bear Avenue, now known as "Suburban Pond". The more effective use of the storage available in Suburban Pond significantly reduced the peak rate of discharge from this drainage area into Battle Creek. The three drainage areas flowing into Suburban Pond are identified as C-58, C-59-1, and C-60. These drainage areas are discussed below.

C-58—This drainage area is approximately 204 acres in size with 107 acres of residential and 97 acres of commercial. This area drains into the storm sewer system that crosses under I-94 near Hazel Street extended and enters the northeastern corner of Suburban Pond. When high flow rates occur, a portion of the stormwater from C-58 is diverted to C-59-1 through a cross connection along Old Hudson Road between Hazel and Van Dyke.

C-59-1—This drainage area is approximately 128 acres in size with 89 acres of residential and 39 acres of commercial. This area drains into the storm sewer system that crosses under I-94 near Van Dyke extended and enters the north side of Suburban Pond. This system receives diverted stormwater from C-58 as described above.

C-60—This drainage area is approximately 58 acres in size and primarily consists of commercial property including car dealerships, a Target Store, and miscellaneous small businesses and shops along Suburban Ave. Also, a large portion of the drainage area is Suburban Pond itself.

3.2 Ruth Street Subwatershed

The Ruth Street Subwatershed is comprised of 12 individual drainage areas, which flow into Battle Creek between the flood flow inlet (about 450 feet upstream of Upper Afton Road) and McKnight Road. These 12 storm sewer systems range in size from 12" to 36" diameter pipes. The sand and silt entering these storm sewer systems is conveyed directly into the Battle Creek channel. These materials are either deposited immediately in the creek bed or carried downstream where they tend to be deposited in the low-flow channel. This study determined that nine of these storm sewer systems serve residential areas and are not high contributors of sand and silt. The three other storm sewer systems contribute the majority of the sand and silt from this subwatershed. These three drainage areas are described below.

C-62—This drainage area is approximately 70 acres in size with 42 acres of residential and 28 acres of commercial. The drainage area is bounded by Valleyside Drive on the west, Pedersen Street extended on the east, Suburban Avenue on the north, and Battle Creek on the south. This area drains to Battle Creek at Ruth Street.

C-63—This drainage area is approximately 46 acres in size with 13 acres of residential, 14 acres of commercial and 19 acres of school/park land. The drainage area is bounded by Pedersen Street extended on the west, Suburban Avenue extended on the east, I-94 on the north, and Battle Creek on the south. The area drains to Battle Creek at Winthrop Street extended.

C-65-8—This drainage area is approximately 30 acres of commercial development and apartments. The area is bounded by Suburban Avenue extended on the west, McKnight Road on the east, Wilson Avenue on the north, and Battle Creek on the south. This area drains to Battle Creek at McKnight Road.

3.3 Upper Afton Road Subwatershed

The Upper Afton Road Subwatershed is comprised of three individual drainage areas which flow into Battle Creek at Upper Afton Road. A special structure at Upper Afton Road routes the low flows into the Battle Creek (the aboveground low-flow channel) and diverts most of the higher flood flows into the underground flood flow storm sewer system. This study determined that one of these drainage areas (C-61) serves a residential area and is not a high contributor of sand and silt. The other two drainage areas contribute the majority of sand and silt from this subwatershed. These two drainage areas are described below.

C-59-2—This drainage area is approximately 85 acres in size with 3 acres of residential and 82 acres of commercial. The drainage area is bounded by Hazel Street on the west, McKnight Road on the east, Old Hudson Road on the north, and Burns Avenue on the south. It drains the Sunray Shopping Center and also I-94 from Hazel to McKnight. This area has the highest percentage of parking lot surface of all the areas in the study.

C-66—This drainage area is approximately 57 acres in size with 42 acres of residential and 15 acres of school and parkland. The drainage area is bounded by Battle Creek Road on the west, Winthrop Street on the east, Darlene Court on the north, and Longfellow Avenue on the south.

4.0 Sand/Silt Sources

4.1 Winter Road Sands

Predicting the amount of winter road sand that enters a storm sewer system is very difficult. Numerous variables impact the amount of sand that is used and how much of the sand used actually enters the storm sewer system. Monitoring and sampling can quantify the amount for a particular sequence of conditions but each particular sequence of conditions is unlikely to recur on a predictable basis.

Variability in the weather affects the number of events each year requiring the application of road sand. The quantity of sand used for each event is likely to vary with the severity of the event. Other variables include type of roadway (residential, commercial, interstate), traffic volume, roadway grades, curves, intersections, and rail crossings. The weather, and many of these same factors, affect the amount and the rate at which the sand finds its' way into the storm sewer system. The photo below shows just one such source of sand and silt (melting snow pile containing sand in a shopping center parking lot). Intense spring rainfall events, before roadways can be swept, can transport large quantities of sand and silt into the storm sewer system. When the intense spring rainfall events do not occur before the roadways are swept a significant reduction in the quantities reaching the storm sewer system occurs.

While it seems intuitive that measuring the quantity of sand applied each season and comparing that with the quantity swept up each season should reveal the quantity entering the storm sewer system, available data do not demonstrate this result. The City of St. Paul, as well as the City of Minneapolis, have stated that they usually collect more sand and silt by sweeping than they applied during the winter season. Other sources of sand that cannot be accounted for are commercial and multiple residential parking lot, state and county roadways, and adjacent communities. A reliable inventory to account for lost sand would require data from a considerable number of private and public owners of paved surfaces; data which is not, and is not likely to become, available. A different approach is needed to estimate the quantity of sand and silt entering the storm sewer system on an annual basis.

The Cities of St. Paul and Minneapolis, as well as the Minnesota Department of Transportation (Mn/DOT), furnished historical data regarding the average annual rates of road sand application. This application data was converted from land miles to cubic yards of road sand applied to an acre of roadway surface. This data is presented below.

Metro Area Average Application Rates

City of St. Paul	6.78 cubic yards per acre of roadway a year
City of Minneapolis	5.70 cubic yards per acre of roadway a year
MN/Dot	6.10 cubic yards per acre of roadway a year
Average =	6.19 cubic yards per acre of roadway a year

These rates were calculated from data over the past few years. The rates may change gradually in the future as some agencies change their attitude toward use of road sand. For example, Mn/DOT is using more deicing chemicals and less sand in response to the driving publics demand to drive on snow free road rather than snow packed roads. Mn/DOT is applying more salt and chemicals to melt snow and ice. Mn/DOT is also using less sand to reduce the adverse impacts related to siltation of ditches, culvert, and storm sewers. Finally, studies have shown that sand is not that effective on the suburban highways with large volumes of traffic. It only takes a few vehicles to quickly track the sand off of the driving lanes.

The following table was developed based on the "Road Management Journal, Annual Raod Sand Application Rate Chart, Average Rates." The rates in the first column are per application. The annual rates in the third column are based on 12 applications per average winter season. It is of note that based on this table the metro area averages described above would be classified as light applications. However, roadway slope, traffic lights, stop signs, curves, and public demand affect the actual distribution. The table includes some guidance related to roadway slopes.

For the purpose of this study, we assumed that approximately 10 percent of the annual road sand applied to the road surface ends up in the storm sewer system (the fourth column in the following table). It is our opinion that based on the quantities of sand applied this may be conservatively low.

The following table shows an estimate of the quantity of sand applied to the different areas within this study.

Annual Road Sand Application Rate Chart

Cubic Yards Per Acre	Rate Applied	*Yearly Annual Rate In Cubic Yards Per Acre Applied to Road Surface	10% of Sand Into Storm Drain	Grade Scale Value
16.81	Outrageously Heavy	201.72	20.172	
8.40	Extremely Heavy	100.80	10.080	
4.20	Very Heavy	50.40	5.040	Very Steep Slope = over 8%
2.10	Heavy	25.20	2.520	Steep Slope = 4 to 8%
1.05	Moderate	12.60	1.260	Normal Slope = 2 to 4%
0.53	Light	6.36	0.636	Flat Slope = 0 to 2%

*Average of 12 applications per year for an average winter.

The heavy rate was applied to the commercial parking lot areas based on observations of commercial sites in the study area. Based on the above application rate chart the total sand loads for each drainage area have been calculated and are shown in Figure 5 and Figure 6. The annual quantity of sand loading from road sand applications and parking lots was calculated to be 236 cubic yards of sand from all the contributing areas. Of the total, 153 cubic yards enters directly into Battle Creek (Figure 5) and 83 cubic yards deposited into Suburban Avenue Pond (Figure 6).

4.2 Creek Bank Erosion

Natural streams are dynamic landforms subject to gradual changes in channel shape and flow patterns. Creek bank erosion is influenced by many factors including peak flow rates, base flow rates, sediment loads, and channel width, depth, meander wavelength and gradient (slope).

Dimensionless characteristics of stream channel and types of pattern (braided, meandering, straight) and sinuosity are used to characterize channels that act to minimize the occurrence of creek bank erosion. The uncontrolled creek bank erosion which occurred prior to 1983 was repaired and restored as part of the Battle Creek Restoration project and the re-established creek channel results in minimal creek bank erosion. Based on field observations of the creek from McKnight Road to Highway 61, the channel in this reach is, as intended, experiencing very low rates of bank erosion. The reach of Battle Creek from McKnight Road to Upper Afton Road has shown little change since the renovations of 1983. In the reach from Upper Afton Road to Highway 61 the creek channel experienced sedimentation rather than bank erosion. In lieu of an extensive monitoring program, the minor amount of sediment resulting from creek bank erosion has been estimated for this study based on flow distance along the creek channel from each drainage area outfall to the creek and the average flow rate in the creek. These estimated quantities are shown in Figures 5 and 6.

4.3 Construction Site Erosion and Tracking

Site visits in November and December 2001 identified only three active construction sites in the entire drainage area. One site was commercial construction and included erosion control devices. However, as is often the case, a primary contributor of soil leaving a construction site is tracking by construction vehicles leaving the site. On this day, the tracking from this site resulted in one driving lane for one and a half blocks being covered with dirt from the construction site. No indications that the road was being swept were observed.

A second site was new residential construction with a fairly steep grade from the structure to the roadway. There were no erosion control devices, not even silt fencing, in place to prevent sediment from being washed out onto the roadway. Construction vehicles tracking soil off of the site was also a significant contributor to the roadway accumulation. Once on the roadway the sediment was being spread by traffic.

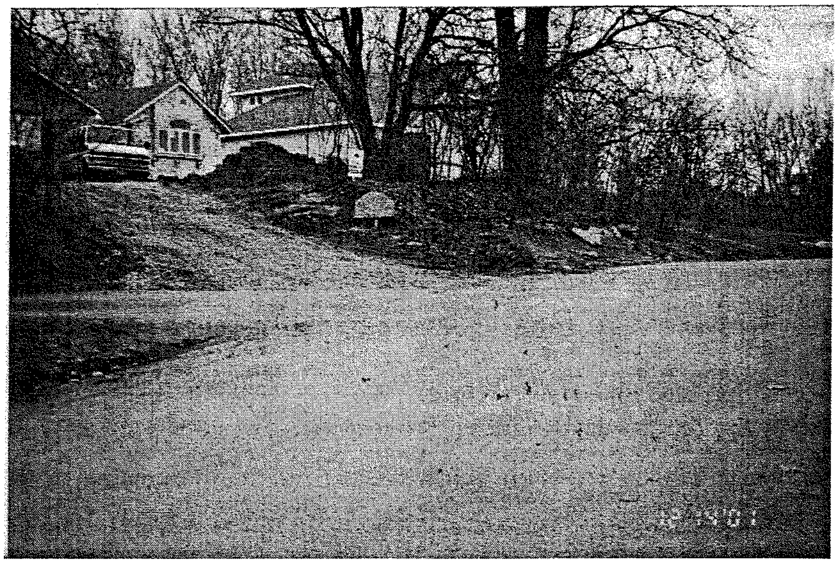


Photo of residential construction site on White Bear Ave. near "C" Street with no erosion control practices being used.

A third construction site was a sewer or water main repair that had just been completed. An area of pavement had been removed for the excavation and, after the repair was completed, the excavation was backfilled with soil materials until it was flush with the adjacent pavement. During daily freeze/thaw cycles and rainfall events the soil materials had been eroded, splashed, and/or tracked from this small, unprotected area. Temporary bituminous pavement would prevent the transport of soil materials to the sewer system and eventually in the creek.

Erosion from construction sites can be responsible for large amounts of sediment being conveyed into the storm sewer system and conveyed to lakes, ponds, and creeks. However, the study area is mostly developed and construction activities are likely to be limited in scope and number. For the purposes of this study, a small factor was used to account for the annual sediment load from construction sites. These estimated quantities are shown in Figures 5 and 6.

4.4 Erosion from streets without curb and gutter

There are portions of a couple of streets in the study area where paved roadways do not have curb and gutter. The street drainage was directed to the edge of the roadway paving were erosion takes place, washing away the soil adjacent to the pavement. The following photographs show a portion of Battle Creek Road where this type of erosion is occurring. In at least one location an eroded area adjacent to the pavement had been filled but the new fill was already washing away directly into a nearby catch basin. An estimate of the sediment loading due to this type of erosion was added and is shown in Figure 5 for drainage area C-66.

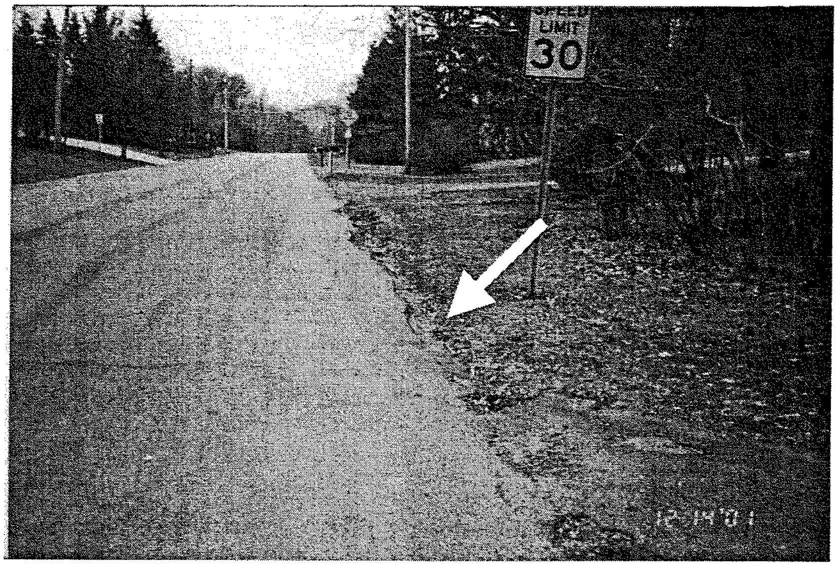


Photo of erosion at edge of Battle Creek Road just south of Upper Afton Road

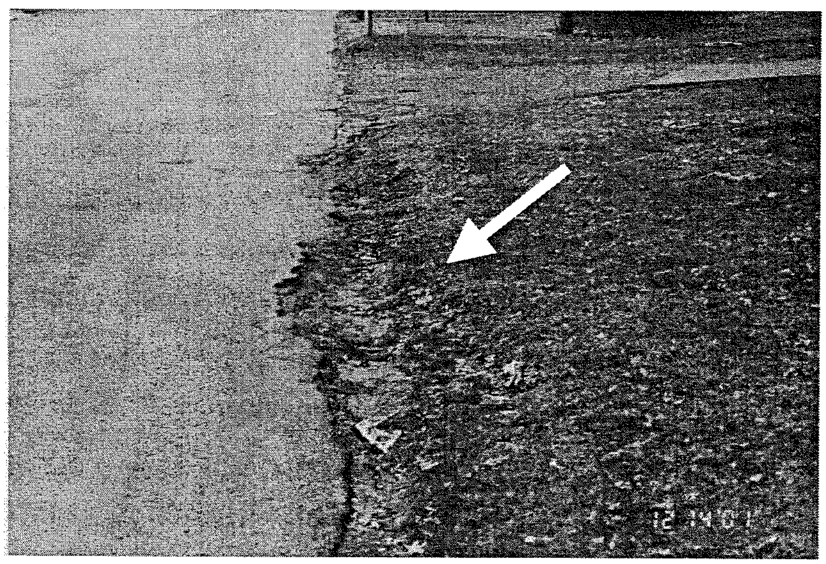


Photo of erosion at edge of Battle Creek Road a little closer to Upper Afton Road

4.5 Seal-Coating

One portion of the study area had been seal-coated in the fall of 2001 and although it had been cleaned up earlier in the season there was still evidence of the seal-coating materials in the gutters and catch basins. A small area of the low-flow channel bottom sediments, just downstream from Upper Afton Road, was sampled in the fall of 2001. Seal-coating material was evident in the samples. A small loading factor was used for all pavement areas based on an estimated annual average contribution of seal coating materials to the low-flow creek channel. These estimated quantities are shown in Figures 5 and 6.

5.0 Estimated Sediment Loads

Figures 5 and 6 summarize the estimated loading from each of the described sources for each of the drainage areas described. Figure 5 includes all areas contributing flow to Battle Creek, except for the Suburban Pond drainage area, from McKnight Road down to an including Upper Afton Road. Figure 6 includes all areas contributing flow to Suburban Pond since this sediment load is directed towards Suburban Pond and does not reach Battle Creek.

6.0 Materials Other Than Sand and Silt

Although, sands and silt are one of the primary contributors to the sedimentation that continues to occur in the Battle Creek channel, there are, however, other materials conveyed by the stormwater that contribute to the accumulation in the low-flow channel. These materials include grass clippings in the summer, leaves in the fall, twigs/branches/woody material, and trash. These materials also enter the storm sewer system, are conveyed to the creek channel and get trapped, along with the sand and silt, in the grasses and cattails growing in and adjacent to the low-flow channel. The debris, sand, and silt provide a bed for further vegetative growth and the cycle tends to continue. Any plan to manage sand and silt in the drainage area should also identify actions to address these other materials and the channel vegetation as well.

7.0 Sediment Control Alternatives Considered

7.1 Suburban Pond Subwatershed

The sand and silt load from the Suburban Pond Subwatershed is summarized on Figure 6. It should be noted that over 50 percent of the load from this subwatershed is due to roadway sanding from St. Paul City streets and the tributary area of I-94. A large portion of this sand and silt load appears to settle within the storm sewer as it crosses under I-94 and Suburban Avenue. Very little of the sediment actually reaches Suburban Pond. The amount that does gets deposited near the inlet into the pond and, thus, does not discharge from the pond and impact the rate of accumulation of sediment in the Battle Creek Channel. However, the accumulation of sediment in the storm sewer in I-94 does reduce the capacity of the system. No sediment control alternatives were identified for this subwatershed. Since drainage through this pipeline is runoff from the City of St. Paul and from the Mn/DOT highway system, this storm sewer is a community/Mn/DOT drainage and maintenance responsibility. The sediment needs to be removed from the pipe now and will need to be removed periodically in the future.

7.2 Ruth Street and Upper Afton Road Subwatersheds

Alternative watershed management approaches may result in more efficient and cost effective solutions to maintain the aesthetics and flow characteristics of the creek channel through the lower ravine. Therefore, alternatives have been identified to reduce or eliminate the quantities of sand and silt that is being conveyed to the Battle Creek low-flow channel. These alternatives, along with a "No New Action" alternative, are discussed briefly in the following paragraphs.

7.3 No New Action

This alternative involves no changes within the study area's watershed. Based on past experience this "No New Action" alternative would continue to involve a clean out of the Battle Creek low-flow channel every 5 years at an approximate cost of $100,000 per cleaning (2002 dollars).

7.4 Stormwater Settling Basins

This alternative involves the construction of open water basins that collect stormwater and cause particulate matter in the stormwater to "settle" out. This alternative requires a significant amount of space to construct the basin (rule of thumb 1 acre of basin area per 20 acres of residential drainage area) and suitable existing storm sewer elevations that would allow the construction of such a basin without major storm sewer alterations. This alternative does not address the impact of vegetative accumulations in the lower ravine low-flow channel. These vegetative accumulations will impact the frequency of the channel cleaning required with this alternative.

7.4.1 Site 2: Battle Creek just downstream of Upper Afton Road

As a part of the 2002 Battle Creek Lower Ravine Cleaning project, a small settling basin was excavated at the end of low-flow diverter pipe to collect sand and silt. In addition, an access pad was graded near the existing bridge to facilitate cleaning out of this basin on a regular basis. Ramsey County Parks has verbally committed to cleaning this collection area routinely. Due to its small size and limited sediment collection capacity, the cleaning frequency may be as often as monthly. Because the excavation and grading work was conducted as a test project, the scope of the construction of this facility resulted in grading work that was relatively minor and inexpensive. Site restrictions limited the basin size and sediment storage capacity. The effectiveness of this basin as well as the maintenance requirements should be monitored and if the test project and joint venture with Ramsey County Parks appears successful, the basin could be enhanced to increase its effectiveness. The improvement expected will be very limited unless used in combination with other measures. The preliminary estimated cost for additional work at this site is $75,000 with estimated annual costs of $8,000 for sand and silt removal.

7.4.2 Site 5A: Ruth Street just south of North Park Drive

This alternative would redirect low flows from the 33-inch storm sewer in Ruth Street into a new settling basin just south of North Park Drive adjacent to Battle Creek. The preliminary estimated cost for the work involved to construct this basin and complete storm sewer modifications is estimated to be $200,000 with estimated annual costs of $5,000 to remove accumulations from the basin.

7.5 Grit Chambers

This alternative would involve the installation of underground grit collection chambers at key locations within the study watershed to capture sand and silt before these materials can enter Battle Creek. Examples of grit chambers are Stormceptor-type devices. These devices have the appearance of a large manhole and they operate by altering the hydraulics of the storm flow in such a way as to encourage particulate matter in the stormwater to settle out in the chamber's collection area. High flows by-pass the chamber to maintain the systems flood flow carrying capacity.

Grit chambers to trap sediment would be an effective addition to most all large-scale developments. Also using individual site grit chambers should be evaluated for long-term effectiveness. Whether for large-scale redevelopments or individual sites unless grit chambers are cleaned out on a regular basis their effectiveness is likely to diminish to near zero in about a year. While developers may agree to clean out the sediment on a regular basis it seems unlikely that end users/owners would actually implement such a program. A District enforcement or maintenance program may be required to assure effectiveness. The costs of the District enforcement or maintenance need to be evaluated as part of any decision to implement grit chambers for either large-scale redevelopments or for individual sites.

A number of sites have been identified within the study area's watershed where grit chambers can be implemented to reduce the quantities of sand and silt being conveyed to Battle Creek. The effectiveness of the grit chambers would be dependent upon routine maintenance to remove accumulated materials. If maintained properly, the grit chambers can achieve a total suspended solids (TSS) removal rate of 50 to 70 percent depending on the design. It is anticipated that accumulated materials will need to be removed a minimum of three times each year to keep the grit chambers functioning effectively. The grit chamber/settling basin sites are shown on Figure 7. This alternative does not address the impact of vegetative accumulations in the lower ravine low-flow channel. These vegetative accumulations will impact the frequency of the channel cleaning required with this alternative.

7.5.1 Site 3: I-94 and Pederson

Install two grit chambers on 36-inch storm sewer system draining Sun-Ray Shopping Center and I-94 (C-59-2). The C-59-2 drainage area is the greatest contributor of sand and silt in the study area and these grit chambers would serve about 1/3 of the total drainage area. The preliminary estimated cost for work at this site is $150,000 with estimated annual costs of $8,000 to clean sand, silt, and debris from the grit chambers.

7.5.2 Site 4: Extended Hazel St. just south of Burns

Install a large grit chamber on the existing 66-inch storm sewer in the vicinity of Hazel Street extended and Burns Avenue extended just east of Suburban Pond (C-59-2). The C-59-2 drainage area is the greatest contributor of sand and silt in the study area and this grit chamber would serve the remainder of the total drainage area not served by Site 3. The preliminary estimated cost for work at this site is $225,000 with estimated annual costs of $5,000 to clean sand, silt, and debris from the grit chamber.

7.5.3 Site 5: Ruth Street just south of North Park Drive

Another alternative, identified as Site 5B, (in lieu of Alternative 5A above) was considered for this site. Again, Site 5B is located at Battle Creek at Ruth Street and serves drainage area C-62. This alternative involves the installation of a grit chamber on the 33-inch storm drain in Ruth Street just south of North Park Drive. The preliminary estimated cost for the work involved in this alternative is $100,000 with estimated annual costs of $5,000 to clean sand, silt, and debris from the grit chamber.

7.5.4 Site 6: Winthrop just south of North Park Drive

Install a grit chamber on the existing 36-inch storm sewer in Winthrop extended just south of North Park Drive (C-63). The use of a small settling basin was considered at this site. It was determined that a small settling basin was not feasible due to the limited space available and the steep ravine slopes in this reach. The preliminary estimated cost to construct for the grit chamber at this site is $90,000 with estimated annual costs of $5,000 to clean sand, silt, and debris from the grit chamber.

7.5.5 Site 7: McKnight Road just south of North Park Drive

Install a grit chamber on the existing 36-inch storm sewer from McKnight Road just before the outfall into Battle Creek (C-65-8). The use of a small settling basin was considered at this site. It was determined that a small settling basin was not feasible due to the limited space available on the west side of McKnight Road. The preliminary estimated cost to construct the grit chamber at this site is $90,000 with estimated annual costs of $5,000 to clean sand, silt, and debris from the grit chamber.

7.5.6 Site 8: Upper Afton Road and Battle Creek

Install a grit chamber on existing 27-inch storm sewer serving drainage area C-66 in Upper Afton Road near Battle Creek. The preliminary estimated cost for the work involved in this option $90,000 with estimated annual costs of $5,000 to clean sand, silt, and debris from the grit chamber. At this site an option to the grit chamber would be to redirect the 27-inch storm sewer in Upper Afton to the high flow pipe by installing a new rerouted storm drain connecting the existing 27-inch storm drain in Upper Afton to the 90-inch storm drain flood flow pipe. The preliminary estimated cost for the work involved in this option is $100,000 with negligible annual costs.

The total preliminary estimated cost for this grit chamber alternative would be at least $820,000 with an estimated annual maintenance costs of at least $40,000. Assuming a 50 percent removal efficiency for the grit chambers, approximately the grit chambers have the potential to prevent 85 cubic yard of sand and silt from reaching Battle Creek each year.

7.6 Upper Afton Road Diversion

This alternative involves keeping the low creek flows separated from the local stormwater outfalls at Upper Afton Road. The theory behind this is that it will prevent the sediment-laden drainage from the 273 tributary acres from entering Battle Creek low-flow channel downstream of Upper Afton Road. The runoff from this area would bypass the low-flow diversion and be directed into the flood flow storm sewer system. This site is identified as Site 1 on Figure 7. This alternative does not address the impact of vegetative accumulations in the lower ravine low-flow channel. These vegetative accumulations will impact the frequency of the channel cleaning required with this alternative.

At this site the existing creek low flow, high flow and the local storm sewer flow from areas C-59-2, C-61, C-66, and C-71-1, all drain into and through an 8-foot by 6-foot culvert under Upper Afton Road. At the downstream (south) end of this culvert a low-flow separator structure diverts the low flows into the low-flow creek channel. In this structure low-creek flows drop into a trough in the bottom of the structure that is perpendicular to the flow and directs it into a manhole and down a 24-inch pipe that outlets into the low-flow channel. All low flows from the creek and storm drain systems that flow into the culvert will be directed to the low-flow channel until the 24-inch pipe reaches capacity. Then higher flows will overflow the trough and drop into the high (flood) flow pipe system.

If the low creek flow can be kept from mixing with the 273 acres of stormwater that connects into the high flow pipe north of Upper Afton a large amount of silt/sand could be eliminated. This would mean a decrease of approximately 74.6 cubic yards a year of sand and silt to the low-flow channel (or about 1/3 of the total load of 225 cubic yards). It has been assumed based on the remaining sediment load and the impact of vegetative growth that the net impact on the frequency of channel cleaning would be only marginally better than the "No New Action" alternative. Following are two methods of separating the flows by installing a separate pipe for the creek low flows.

A. Install a 24-inch pipe through the inside of the existing 8-foot by 6-foot culvert under Upper Afton for creek low flows. Connect this pipe into the low flow manhole and fill in the low flow trough. Build a new creek low flow inlet at the upstream end of the culvert for the new low flow pipe. The preliminary estimated cost for this work is $40,000.

B. Auger a new 24-inch pipe under Upper Afton for the creek low flows. Construct a new low flow inlet structure and connect this new pipe to the low flow manholes. The preliminary estimated cost for this work is $75,000.

Of the two options we would recommend (A.) the installation of the 24-inch pipe inside of the culvert. Even though the installation of this 24-inch pipe inside of the existing culvert would reduce the cross-sectional area of the existing culvert, it would contain flow that is part of the overall total capacity of the culvert. Also (A.) would disturb less of the park area during the construction.

7.7 Street Sweeping Improvements

Often times when Cities are approached by the District (or other agencies involved in integrated natural resource management) and asked to increase their frequency of street sweeping and improve their effectiveness, they respond by saying they just don't have the resources to do it. Two alternatives associated with this common response are discussed below for consideration.

A. Funding assistance provided to the City of St. Paul to be applied directly to their street sweeping program. The District would specify target areas within the study area watershed and frequency and timing of the sweepings would be determined by the District. The effectiveness of this program could be evaluated for not only a reduction in sediment loads to Battle Creek's lower ravine, but also applied to all urban areas.

B. District purchase a vacuum type street sweeper and coordinate with appropriate St. Paul staff member(s) in training and operating the sweeper. The District would specify target areas within the study area watershed and frequency and timing of the sweepings would be determined by the District. The effectiveness of this program could be evaluated for not only a reduction in sediment loads to Battle Creek's lower ravine, but also applied to all urban areas.

7.8 High Lift Vacuum Truck

A high lift vacuum truck would be an alternative to using a vacuum assisted street sweeper. While the vacuum truck would likely be slower than the street sweeper, the vacuum truck provides more versatility than the street sweeper. The vacuum truck could not only clean accumulated trash and sediment in the curb and gutters but could also be used to clean catch basins, grit chambers and storm sewer outfalls. The vacuum truck could collect sand, silt, and debris wherever these materials accumulate. Regular street sweeping by the City of St. Paul would continue, and the vacuum truck would be used between sweepings in the high load areas to remove sand, silt, and debris. The capital cost to purchase equipment dedicated to the District's use has been included in the cost summary. Other options, such as leasing, rental, or contracting could also be considered in an attempt to reduce the costs further. As with the street sweeper, the same two alternatives apply to the vacuum truck:

A. Funding assistance to the City of St. Paul; and

B. District purchase of vacuum truck in cooperation with the City of St. Paul.

8.0 Conclusions and Recommendations

Winter sanding of roadways and parking lots is the primary contributor of sand and silt to Battle Creek in the lower ravine. The quantities of sand applied to these areas each year are dependent upon the weather conditions experienced each year. Those weather conditions can be random and highly variable, and, in turn, the sanding operations are highly variable. However, based on an average year of street and parking lot sanding, and typical runoff events that subsequently convey the sand, trash, and grit into and through the storm sewer system and to the creek, some reduction in material entering the creek can be achieved. But, it is unlikely that any of the alternatives mentioned in this study will achieve 100 percent effectiveness at eliminating all of the sand and silt. The result being that some sand and silt will continue to be accumulating in the lower ravine regardless. In addition, vegetative growth in and adjacent to the creek channel will obscure flow in the creek channel and cause further deposition of material in the channel. Each fall as the vegetation in the channel goes dormant, the decaying leaves and stems cause further accumulation of organic material in the creek bottom. Therefore, any sediment control measures should be combined with vegetation control in the creek itself.

This study shows that three drainage areas generated over 32 percent of the total sediment load reaching the creek in the lower ravine. Controlling the sediment in these three areas will have the greatest impact in slowing the accumulation of sediment in this portion of Battle Creek. Based on professional judgment, the sediment being "generated" from the remaining areas is so widely scattered that effectively reducing the overall load to the creek over such a large combined area was determined to be very costly and infeasible. The three areas generating this concentration of sediment to Battle Creek in the lower ravine are:

- The Sunray Shopping Center and that portion of I-94 draining to the existing storm sewer system east of Suburban Pond (Drainage Area C-59-2)
- The area south of Suburban Pond and draining to Battle Creek just upstream of Upper Afton Road (Drainage Area C-61)
- Upper Afton Road nearest the Battle Creek Crossing (Drainage Area C-66)

8.1 Summary of Alternatives/Costs Analyzed

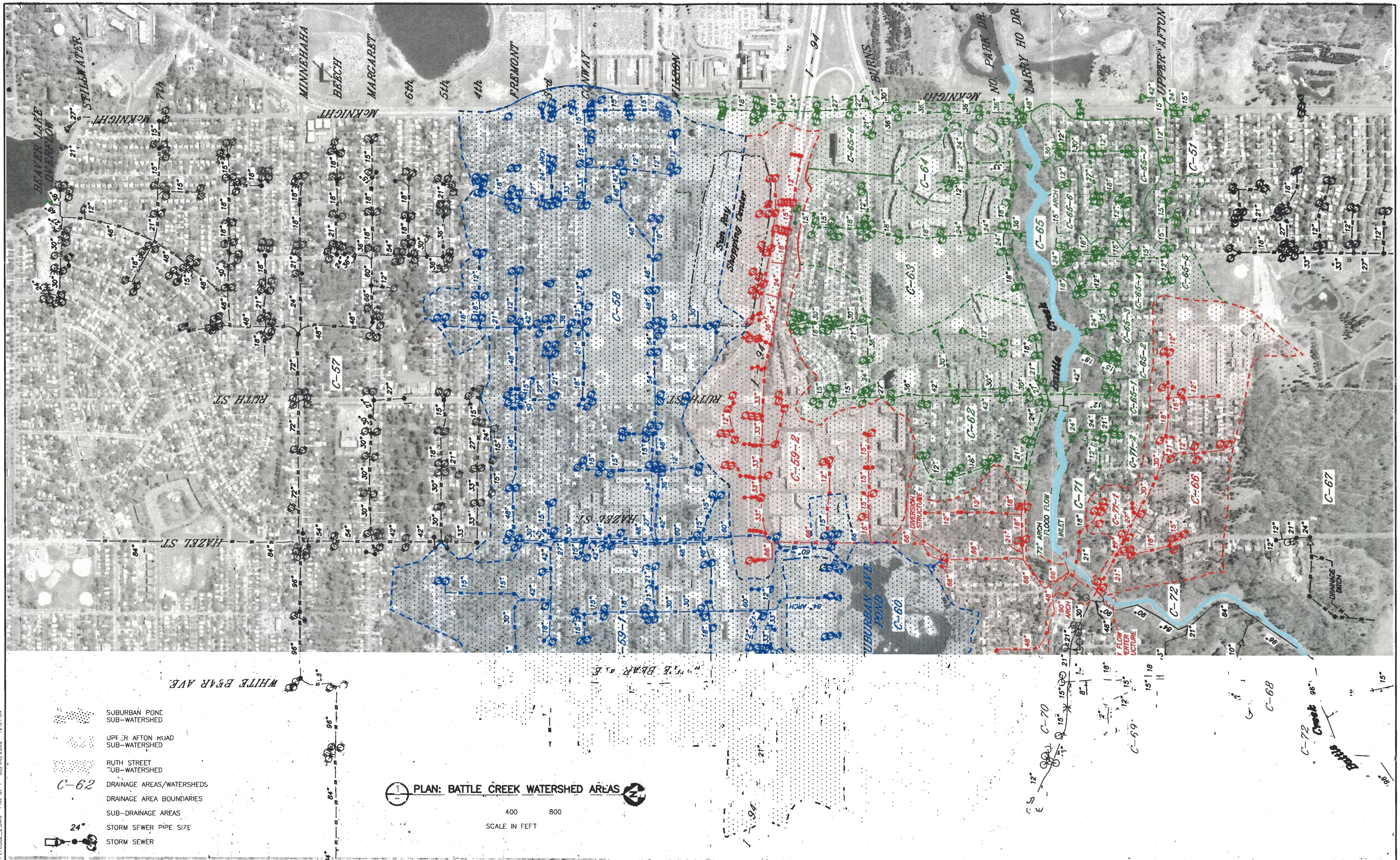
The following table reflects the estimated total dollars expended over a 20-year economic life. Capital costs are in 2002 dollars while annual maintenance and creek cleaning costs assume an average annual inflation rate of 3%. While alternative economic analyses could be used, the following table is representative of the comparative costs based on a 20-year economic life.

Alternative	Capital Cost	Annual Maintenance Cost	Time Between Creek Cleanings	Total Cost Based on 20-Year Life
No new action – Clean Channel Every 5 years[1]	0	0	5	$587,000
Construct permanent settling basin in creek	250,000	$13,000	9	$900,000
Install Six high-capacity grit chambers	745,000	$33,000	9	$1,912,000
Install diversion pipeline in existing culvert	70,000	$3,000	6	$598,000
Purchase street sweeper	250,000	$50,000	10	$1,862,000
Vacuum truck	200,000	$50,000	9	$1,842,000

[1] Cost per cleaning $100,000 (2002 $)

Based on the results of this study and past experience with the accumulation of sediment, vegetation and debris within Battle Creek's Lower Ravine, the most feasible approach to managing the sediment in the Lower Ravine is to clean the channel every 5 years. This approach will be the least costly and will achieve the desired results. It should be noted, however, that as part of a targeted street sweeping program throughout the District the cost to purchase and operate the street sweeper or vacuum truck should be prorated to the areas served. For example, if the equipment was used 30 percent of the time in the Battle Creek watershed, only 30 percent of the cost or $560,000 should be used in the above comparison. This would make the street sweeper or vacuum truck comparable to the cost of no new action.

Figures



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PVJ M:\CAD\2362031\16382_2.DWG Plot at 1 08/06/2002 12:01:04

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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PRINTED NAME BRAD LINDAMAN
DATE ______ REG. NO. ______

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CLIENT							
BID							
CONSTRUCTION							
	DATE RELEASED						

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Corporate Headquarters: Minneapolis, Minnesota
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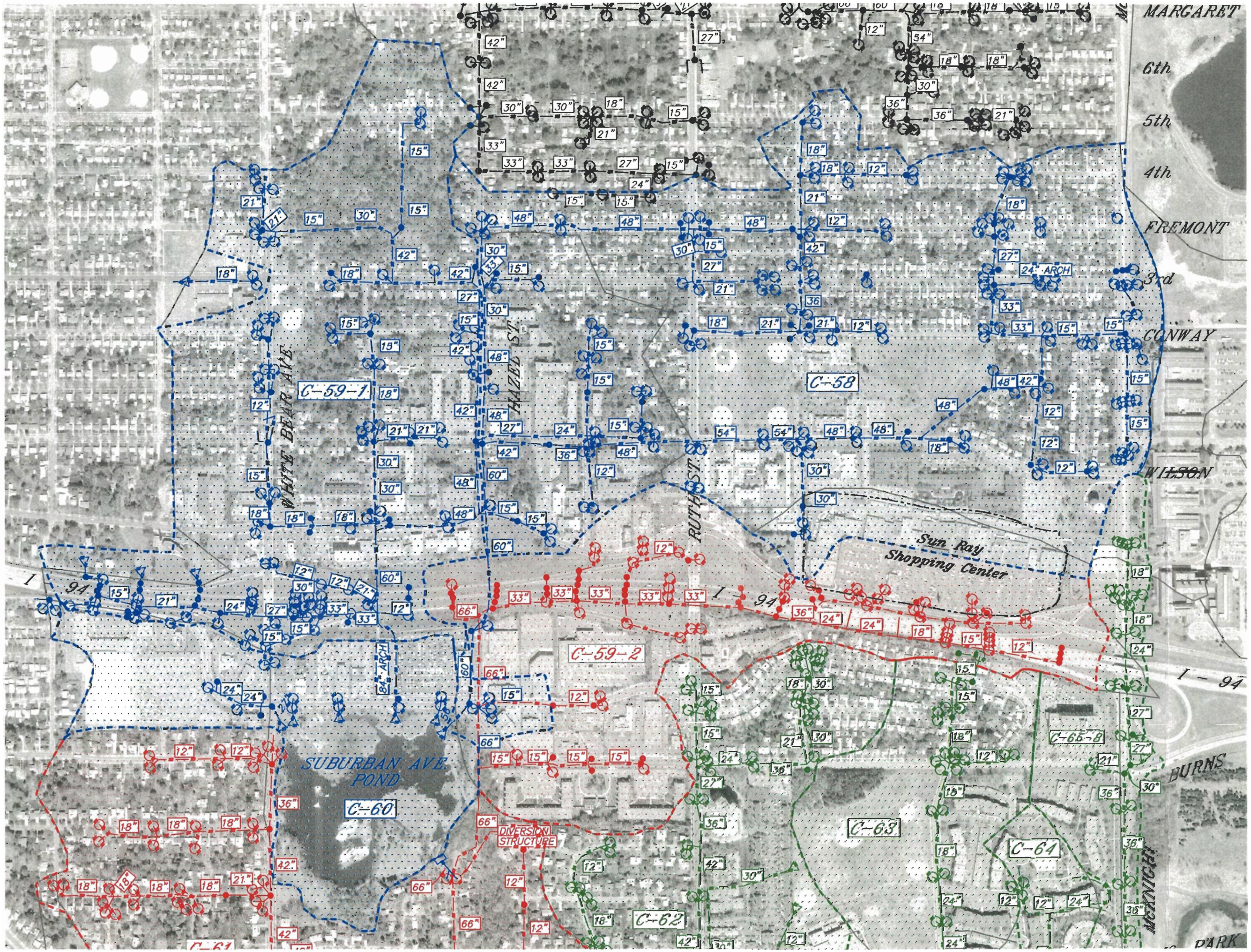
Date	01/17/02
Drawn	PVJ
Checked	JNB
Designed	JNB
Approved	BJL

RWMWD
St. Paul, Minnesota

BATTLE CREEK SILTATION STUDY
Metro Watershed District

WATERSHED DRAINAGE AREAS

BARR PROJECT No. 23/62-031-010
CLIENT PROJECT No.
DWG. No. Figure 1
REV. No.



1 PLAN: SUBURBAN AVE. POND DRAINAGE

SCALE AS SHOWN

0 300 600 SCALE IN FEET

SUBURBAN POND SUB-WATERSHED

UPPER AFTON ROAD SUB-WATERSHED

RUTH STREET SUB-WATERSHED

C-62 DRAINAGE AREAS/WATERSHEDS

DRAINAGE AREA BOUNDARIES

SUB-DRAINAGE AREAS

24" STORM SEWER PIPE SIZE

STORM SEWER

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Approved	BJL

RWMWD

St. Paul, Minnesota

BATTLE CREEK SILTATION STUDY

Metro Watershed District

AREA CONTRIBUTING SILT TO SUBURBAN AVENUE POND

BARR PROJECT No. 23/62-031-010

CLIENT PROJECT No.

DWG. No. Figure 2

REV. No.

Xrefs in Drawing - M:\cad\2362031\15981_2.dwg
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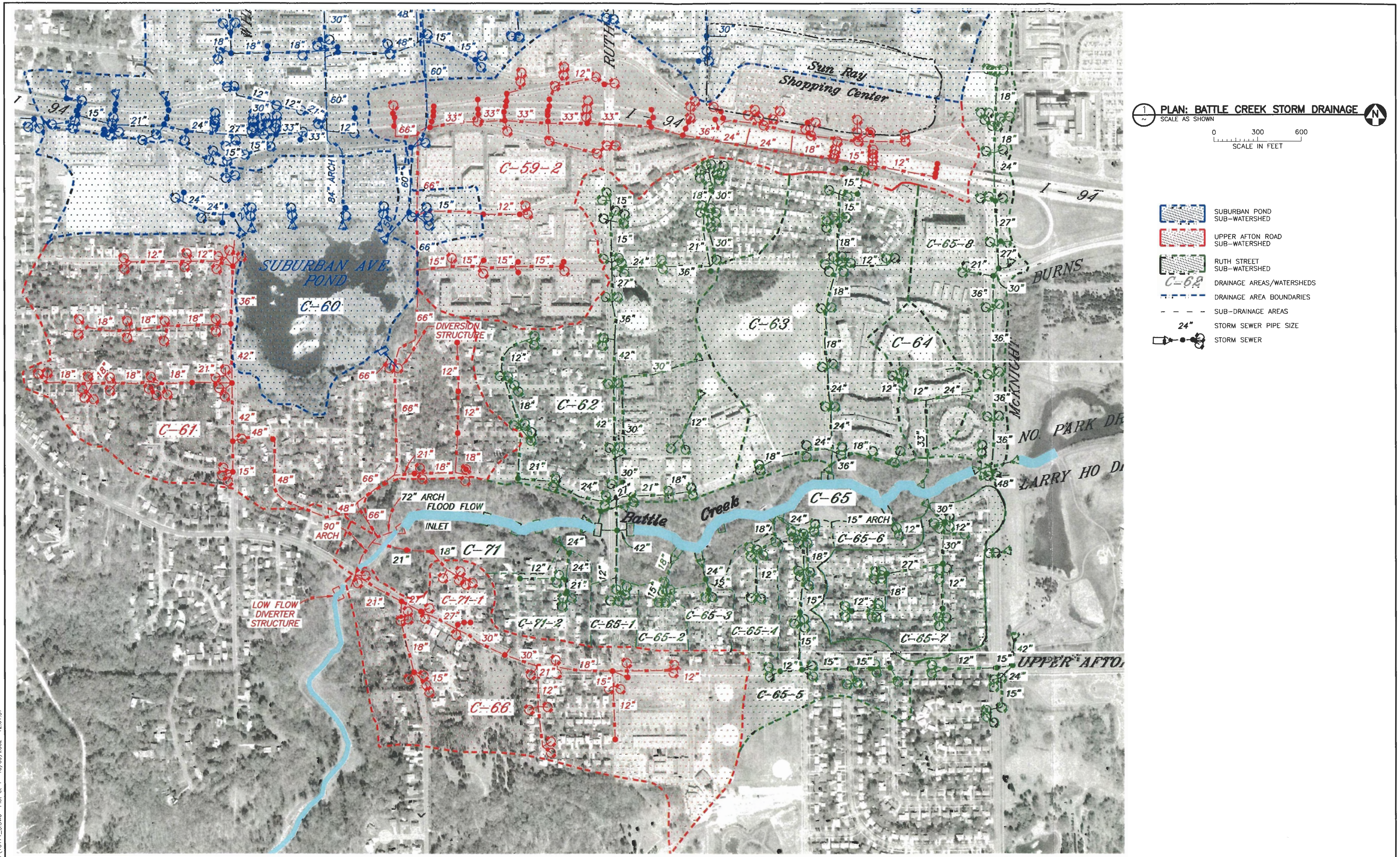

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Approved	BJL

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St. Paul, Minnesota

BATTLE CREEK SILTATION STUDY
Metro Watershed District

AREAS DRAINING INTO PIPE UP-STREAM OF UPPER AFTON RD PRIOR TO LOW CREEK FLOW DIVERTER

BARR PROJECT No. 23/62-031-010

CLIENT PROJECT No.

DWG. No. Figure 3

REV. No.

Ramsey Washington Metro Watershed District

Battle Creek Siltation Study

Drainage Area Data Chart

3/18/02 JNB

Drainage Area No.	Total Acres	Pervious Acres	Impervious Acres	Roadway Acres	Drive/ Parking Lot Acres	Slope of Area	Com. Acres	Res. Acres
C-58	203.8	129.4	74.4	19.4	26.1	Normal	97.3	106.5
C-59-1	128.4	78.9	49.4	19.4	16.5	Normal	38.9	89.5
C-59-2	85.2	30.6	54.6	15.0	27.4	Normal	82.4	2.8
C-60	58.4	34.2	24.1	2.6	17.1	Normal	58.4	0.0
C-61	83.4	61.0	22.4	7.8	4.9	Normal	0.0	83.4
C-62	69.7	33.0	36.7	7.3	12.7	Steep	27.5	42.2
C-63	46.4	13.3	33.1	5.2	2.5	Steep	14.3	13.4
C-64	10.4	6.4	4.1	1.0	1.0	Steep	10.4	0.0
C-65-1	3.9	1.8	2.1	0.7	0.2	Steep	0.0	3.9
C-65-2	2.9	1.6	1.3	0.7	0.2	Very Steep	0.0	2.9
C-65-3	3.6	1.6	2.0	0.7	0.2	Very Steep	0.0	3.6
C-65-4	5.0	2.3	2.7	0.9	0.3	Steep	0.0	5.0
C-65-5	19.1	5.5	13.6	1.9	0.7	Steep	0.0	19.1
C-65-6	1.4	0.9	0.5	0.4	0.1	Normal	0.0	1.4
C-65-7	16.4	6.4	10.0	2.3	0.8	Steep	0.0	16.4
C-65-8	30.4	14.1	16.3	6.0	4.3	Steep	22.4	0.0
C-66	56.7	44.5	12.2	5.3	2.1	Steep	14.7	42.0
C-68	10.7	1.7	9.0	1.0	0.3	Very Steep	0.0	7.1
C-71-1	4.0	2.6	1.4	0.4	0.3	Very Steep	0.0	4.0
C-71-2	8.0	3.4	4.6	1.1	0.5	Steep	0.0	8.0
Totals =	847.7	473.3	374.6	99.1	118.1		366.3	451.3

#230332

Normal Slope = 2 to 4 %
Steep Slope = 4 to 8%
Very Steep Slope = over 8%

Figure #4

Ramsey Washington Metro Watershed District

Areas Contributing Silt and Sand to Battle Creek Low Flow Channel

Battle Creek Siltation Study

3/18/02 JNB

Drainage Area No.	Total Acres	Pervious Acres	Impervious Acres	Roadway Acres	Miles of 2 Lane Rd.	Rate of Sand Applied	Cubic Yards of Road Sand	Drive/ Parking Lot Acres	Total Road & Parking Sand Load Cub. Yds.	Construction Site Erosion Cub. Yds.	Creek Bank Erosion Cub. Yds.	Unimproved Street Erosion Cub. Yds.	Fines From Seal Coat Cub. Yds.	* Total Sand Load per Area Cub. Yds.
C-59-2	85.2	30.6	54.6	15.0	3.87	Moderate	18.9	27.4	32.8	3.2	0	0	1.1	37.1
C-61	83.4	61.0	22.4	7.8	2.01	Moderate	9.8	4.9	12.3	3.1	0	0	0.6	16.0
C-62	69.7	33.0	36.7	7.3	1.88	Heavy	18.4	12.7	24.9	2.6	8.3	0	0.5	36.3
C-63	46.4	13.3	33.1	5.2	1.34	Heavy	13.1	2.5	14.4	1.7	5.0	0	0.4	21.5
C-64	10.4	6.4	4.1	1.0	0.26	Heavy	2.5	1.0	3.0	0.4	4.2	0	0.1	7.7
C-65-1	3.9	1.8	2.1	0.7	0.18	Heavy	1.8	0.2	1.9	0.1	3.7	0	0.1	5.8
C-65-2	2.9	1.6	1.3	0.7	0.18	Very Heavy	3.5	0.2	3.6	0.1	3.2	0	0.1	7.0
C-65-3	3.6	1.6	2.0	0.7	0.18	Very Heavy	3.5	0.2	3.6	0.1	1.9	0	0.1	5.7
C-65-4	5.0	2.3	2.7	0.9	0.23	Heavy	2.3	0.3	2.4	0.2	3.2	0	0.1	5.9
C-65-5	19.1	5.5	13.6	1.9	0.49	Heavy	4.8	0.7	5.1	0.7	3.2	0	0.1	9.2
C-65-6	1.4	0.9	0.5	0.4	0.10	Moderate	0.5	0.1	0.6	0.1	4.2	0	0.0	4.8
C-65-7	16.4	6.4	10.0	2.3	0.59	Heavy	5.8	0.8	6.2	0.6	4.2	0	0.2	11.1
C-65-8	30.4	14.1	16.3	6.0	1.55	Heavy	15.1	4.3	17.3	1.1	3.7	0	0.4	22.6
C-66	56.7	44.5	12.2	5.3	1.37	Heavy	13.4	2.1	14.4	2.1	0	2.3	0.4	19.2
C-68	10.7	1.7	9.0	1.0	0.26	Very Heavy	5.0	0.3	5.2	0.4	0	0	0.1	5.7
C-71-1	4.0	2.6	1.4	0.4	0.10	Very Heavy	2.0	0.3	2.2	0.1	0	0	0.0	2.3
C-71-2	8.0	3.4	4.6	1.1	0.28	Heavy	2.8	0.5	3.0	0.3	3.7	0	0.1	7.1
Totals =	457.2	230.7	226.6	57.7	14.9		123.2	58.5	153.0	16.9	48.5	2.3	4.3	225.0

* Total loads calculated are for one year with average weather conditions

Little Slope = 0 to 2% = Lite Application Rate
Normal Slope = 2 to 4% = Moderate Application Rate
Steep Slope = 4 to 8% = Heavy Application Rate
Very Steep Slope = over 8% = Very Heavy Application Rate

#230332

Figure #5

Ramsey Washington Metro Watershed District

Areas Contributing Sand and Silt to Suburban Pond

Battle Creek Siltation Study

3/18/02 JNB

Drainage Area No.	Total Acres	Pervious Acres	Impervious Acres	Roadway Acres	Miles of 2 Lane Rd.	Rate of Sand Applied	Cubic Yards of Road Sand	Drive/ Parking Lot Acres	Total Road & Parking Sand Load Cub. Yds.	Construction Site Erosion Cub. Yds.	Creek Bank Erosion Cub. Yds.	Unimproved Street Erosion Cub. Yds.	Fines From Seal Coat Cub. Yds.	* Total Sand Load per Area Cub. Yds.
C-58	203.76	129.39	74.37	19.44	5.02	Moderate	24.5	26.06	37.7	7.5	0	0	1.4	46.7
C-59-1	128.38	78.94	49.44	19.38	5.00	Moderate	24.4	16.45	32.8	4.8	0	0	1.4	39.0
C-60	58.36	34.22	24.14	2.60	0.67	Moderate	3.3	17.07	12.0	2.2	0.0	0	0.2	14.3
Totals =	390.5	242.6	148.0	41.4	10.7	Moderate	52.2	59.6	82.5	14.5	0.0	0.0	3.1	100.0

* Total loads calculated are for one year with average weather conditions

Little Slope = 0 to 2% = Lite Application Rate
Normal Slope = 2 to 4% = Moderate Application Rate
Steep Slope = 4 to 8% = Heavy Application Rate
Very Steep Slope = over 8% = Very Heavy Application Rate

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Figure #6